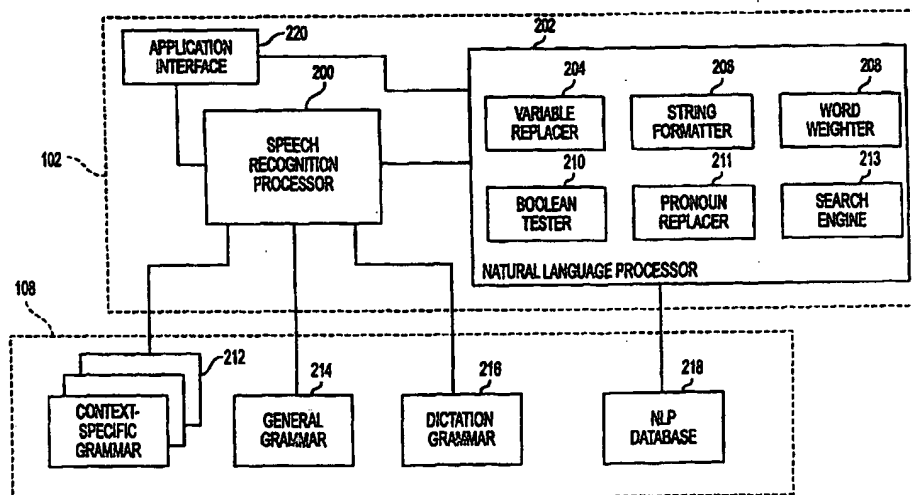




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(54) Title: INTERACTIVE USER INTERFACE USING SPEECH RECOGNITION AND NATURAL LANGUAGE PROCESSING



(57) Abstract

A system and method for interacting with a computer using utterances, speech processing and natural language processing. The system comprises a speech processor for searching a first grammar file for a matching phrase for the utterance, and for searching a second grammar file for the matching phrase if the matching phrase is not found in the first grammar file. The system also includes a natural language processor for searching a database for a matching entry for the matching phrase; and an application interface for performing an action associated with the matching entry if the matching entry is found in the database. The system utilizes context-specific grammars, thereby enhancing speech recognition and natural language processing efficiency. Additionally, the system adaptively and interactively "learns" words and phrases, and their associated meanings.

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INTERACTIVE USER INTERFACE USING SPEECH RECOGNITION AND NATURAL LANGUAGE PROCESSING

BACKGROUND OF THE INVENTION

I. Field of the Invention

5 The present invention relates to speech recognition for computer user interface. More specifically, the present invention relates to a novel method and system for user interface interaction with a computer using speech recognition
10 and natural language processing.

II. Description of the Related Art

As computers have become more prevalent in society it has become clear that many people have great difficulty
15 understanding and communicating with computers. A user must often learn archaic commands and non-intuitive procedures in order to operate the computer. For example, most personal computers use windows-based operating systems which are largely menu-driven. This requires that the user learn what
20 menu commands or sequence of commands produce the desired results.

Furthermore, traditional interaction with a computer is often slowed by manual input devices such as keyboards or mice. Many computer users are not fast typists. As a result,
25 much time is spent communicating commands and words to the computer through these manual input devices. It is becoming clear that an easier, faster and more intuitive method of communicating with computers is needed.

One proposed method of computer interaction is speech
30 recognition. Speech recognition involves software and hardware that act together to audibly detect human speech and translate the detected speech into a string of words. As is known in the art, speech recognition works by breaking down sounds the hardware detects into smaller non-divisible sounds
35 called phonemes. Phonemes are distinct units of sound. For example, the word "those" is made up of three phonemes; the first is the "th" sound, the second is the "o" sound, and the third is the "s" sound. The speech recognition software

attempts to match the detected phonemes with known words from a stored dictionary. An example of a speech recognition system is given in U.S. Patent No. 4,783,803, entitled "SPEECH RECOGNITION APPARATUS AND METHOD", issued November 8, 1998, assigned to Dragon Systems, Inc., and incorporated herein by reference. Presently, there are many commercially available speech recognition software packages available from such companies as Dragon Systems, Inc. and International Business Machines, Inc.

One limitation of these speech recognition software packages or systems is that they typically only perform command and control or dictation functions. Thus, the user is still required to learn a vocabulary of commands in order to operate the computer.

A proposed enhancement to these speech recognition systems is to process the detected words using a natural language processing system. Natural language processing generally involves determining a conceptual "meaning" (e.g., what meaning the speaker intended to convey) of the detected words by analyzing their grammatical relationship and relative context. For example, U.S. Patent No. 4,887,212, entitled "PARSER FOR NATURAL LANGUAGE TEXT", issued December 12, 1989, assigned to International Business Machines Corporation and incorporated by reference herein teaches a method of parsing an input stream of words by using word isolation, morphological analysis, dictionary look-up and grammar analysis.

Natural language processing used in concert with speech recognition provides a powerful tool for operating a computer using spoken words rather than manual input such as a keyboard or mouse. However, one drawback of a conventional natural language processing system is that it may fail to determine the correct "meaning" of the words detected by the speech recognition system. In such a case, the user is typically required to recompose or restate the phrase, with the hope that the natural language processing system will determine the correct "meaning" on subsequent attempts. Clearly, this may

lead to substantial delays as the user is required to restate the entire sentence or command.

Another drawback of conventional systems is that the processing time required for the speech recognition can be prohibitively long. This is primarily due to the finite speed of the processing resources as compared with the large amount of information to be processed. For example, in many conventional speech recognition programs, the time required to recognize the utterance is long due to the size of the dictionary file being searched.

An additional drawback of conventional speech recognition and natural language processing systems is that they are not interactive. As a result, a conversational-style interaction with the computer is not possible. The user is required to communicate complete concepts to the computer. The user is not able to speak in sentence fragments because the meaning of these sentence fragments (which is dependent on the meaning of previous utterances) will be lost.

What is needed is an interactive user interface for a computer which utilizes speech recognition and natural language processing which avoids the drawbacks mentioned above.

SUMMARY OF THE INVENTION

The present invention is a novel and improved system and method for interacting with a computer using utterances, speech processing and natural language processing. Generically, the system comprises a speech processor for searching a first grammar file for a matching phrase for the utterance, and for searching a second grammar file for the matching phrase if the matching phrase is not found in the first grammar file. The system also includes a natural language processor for searching a database for a matching entry for the matching phrase; and an application interface for performing an action associated with the matching entry if the matching entry is found in the database.

In the preferred embodiment, the natural language processor updates at least one of the database, the first grammar file and the second grammar file with the matching phrase if the matching entry is not found in the database.

5 The first grammar file is a context-specific grammar file. A context-specific grammar file is one which contains words and phrases that are highly relevant to a specific subject. The second grammar file is a general grammar file. A general grammar file is one which contains words and phrases which do
10 not need to be interpreted in light of a context. That is to say, the words and phrases in the general grammar file do not belong to any parent context. By searching the context-specific grammar file before searching the general grammar file, the present invention allows the user to communicate
15 with the computer using a more conversational style, wherein the words spoken, if found in the context specific grammar file, are interpreted in light of the subject matter most recently discussed.

20 In a further aspect of the present invention, the speech processor searches a dictation grammar for the matching phrase if the matching phrase is not found in the general grammar file. The dictation grammar is a large vocabulary of general words and phrases. By searching the context-specific and general grammars first, it is expected that the speech
25 recognition time will be greatly reduced due to the context-specific and general grammars being physically smaller files than the dictation grammar.

30 In another aspect of the present invention, the natural language processor replaces at least one word in the matching phrase prior to searching the database. This may be accomplished by a variable replacer in the natural language processor for substituting a wildcard for the at least one word in the matching phrase. By substituting wildcards for certain words (called "word-variables") in the phrase, the
35 number of entries in the database can be significantly reduced. Additionally, a pronoun substituter in the natural language processor may substitute a proper name for pronouns

the matching phrase, allowing user-specific facts to be stored in the database.

In another aspect of the present invention, a string formatter text formats the matching phrase prior to searching the database. Also, a word weighter weights individual words in the matching phrase according to a relative significance of the individual words prior to searching the database. These steps allow for faster, more accurate searching of the database.

A search engine in the natural language processor generates a confidence value for the matching entry. The natural language processor compares the confidence value with a threshold value. A boolean tester determines whether a required number of words from the matching phrase are present in the matching entry. This boolean testing serves as a verification of the results returned by the search engine.

In order to clear up ambiguities, the natural language processor prompts the user whether the matching entry is a correct interpretation of the utterance if the required number of words from the matching phrase are not present in the matching entry. The natural language processor also prompts the user for additional information if the matching entry is not a correct interpretation of the utterance. At least one of the database, the first grammar file and the second grammar file are updated with the additional information. In this way, the present invention adaptively "learns" the meaning of additional utterances, thereby enhancing the efficiency of the user interface.

Lastly, the speech processor will enable and search a context-specific grammar associated with the matching entry for a subsequent matching phrase for a subsequent utterance. This ensures that the most relevant words and phrases will be searched first, thereby decreasing speech recognition times.

BRIEF DESCRIPTION OF THE DRAWINGS

The features, objects and advantages of the present invention will become more apparent from the detailed

description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

5 FIG. 1 is a functional block diagram of an exemplary computer system for use with the present invention;

FIG. 2 is an expanded functional block diagram of the CPU 102 and storage medium 108 of the computer system of FIG. 1 of the present invention;

10 FIGS. 3A-3D are a flowchart of the method of the present invention; and

FIG. 4 is a diagram of selected columns of an exemplary natural language processing (NLP) database of the present invention.

15 **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

The present invention will now be disclosed with reference to a functional block diagram of an exemplary computer system 100 of FIG. 1. In FIG. 1, computer system 100 includes a central processing unit (CPU) 102. The CPU 102 may be any
20 general purpose microprocessor or microcontroller as is known in the art, appropriately programmed to perform the method described herein with reference to FIGS. 3A-3D. For example, CPU 102 may be a conventional microprocessor such as the Pentium II processor manufactured by Intel Corporation or the
25 like.

CPU 102 communicates with a plurality of peripheral equipment, including a display 104, manual input 106, storage medium 108, microphone 110, speaker 112, and data input port 114. Display 104 may be a visual display such as a CRT, LCD
30 screen, touch-sensitive screen, or other monitors as are known in the art for visually displaying images and text to a user. Manual input 106 may be a conventional keyboard, keypad, mouse, trackball, or other input device as is known in the art for the manual input of data. Storage medium 108 may be a
35 conventional read/write memory such as a magnetic disk drive, floppy disk drive, CDROM drive, silicon memory or other memory device as is known in the art for storing and retrieving data.

Significantly, storage medium 108 may be remotely located from CPU 102, and be connected to CPU 102 via a network such as a local area network (LAN), or a wide area network (WAN), or the Internet. Microphone 110 may be any suitable microphone as is known in the art for providing audio signals to CPU 102. Speaker 112 may be any suitable speaker as is known in the art for reproducing audio signals from CPU 102. It is understood that microphone 110 and speaker 112 may include appropriate digital-to-analog and analog-to-digital conversion circuitry as appropriate. Data input port 114 may be any data port as is known in the art for interfacing with an external accessory using a data protocol such as RS-232, Universal Serial Bus, or the like.

Thus, FIG. 1 illustrates the functional elements of a computer system 100. Each of the elements of computer system 100 may be suitable off-the-shelf components as described above. The present invention provides a method and system for interfacing with the computer system 100 using speech.

Turning now to FIG. 2, FIG. 2 illustrates an expanded functional block diagram of CPU 102 and storage medium 108. CPU 102 includes speech recognition processor 220, natural language processor 202 and application interface 220. Natural language processor 202 further includes variable replace 204, string formatter 206, word weighter 208, boolean tester 210, pronoun replacer 211, and search engine 213. Storage medium 108 includes a plurality of context-specific grammar files 212, general grammar file 214, dictation grammar 216, and natural language processor (NLP) database 218. In the preferred embodiment, the grammar files 212, 214, and 216 are Bakus-Naur Form (BNF) files which describe the structure of the language spoken by the user. BNF files are well-known in the art for describing the structure of language, and details of BNF files will therefore not be discussed herein. One advantage of BNF files is that hierarchical tree-like structures may be used to describe phrases or word sequences, without the need to explicitly recite all combinations of these word sequences. Thus, the use of BNF files in the

preferred embodiment minimizes the physical sizes of the files 212, 214, and 216 in the storage medium 108, increasing the speed at which these files can be enabled and searched as described below. However, in alternate embodiments, other file structures are used.

The operation and interaction of these functional elements of FIG. 2 will be described with reference to the flowchart of FIGS. 3A-3D. In FIG. 3A, the flow begins at block 300 with the providing of an utterance to speech processor 200. An utterance is a series of sounds having a beginning and an end, and may include one or more spoken words. Microphone 110 which captures spoken words may perform the step of block 300. Alternately, the utterance may be provided to the speech processor 200 over data input port 114, or from storage medium 108. Preferably, the utterance is in a digital format such as the well-known ".wav" audio file format.

The flow proceeds to decision 302 where the speech processor 200 determines whether one of the context-specific grammars 212 has been enabled. In the preferred embodiment, the context-specific grammars 212 are BNF files which contain words and phrases which are related to a parent context. In general, a context is a subject area. For example, in one embodiment of the present invention applicable to personal computers, examples of contexts may be "news", or "weather", or "stocks". In such a case, the context-specific grammars 212 would each contain commands, control words, descriptors, qualifiers, or parameters that correspond to a different one of these contexts. The use of contexts provides a hierarchal structure for types of information. Contexts and their use will be described further below with reference to the NLP database 218.

If a context-specific grammar 212 has been enabled, the context-specific grammar 212 is searched for a match to the utterance provided at block 300. However, if a context-specific grammar 212 has not been enabled, the flow proceeds to block 308 where the general grammar 214 is enabled.

In the preferred embodiment, the general grammar 214 is a BNF file which contains words and phrases which do not, themselves, belong to a parent context, but may have an associated context for which a context-specific grammar file 212 exists. In other words, the words and phrases in the general grammar 214 may be at the root of the hierarchal context structure. For example, in one embodiment applicable to personal computers, the general grammar 214 would contain commands and control phrases.

In block 310, the general grammar 214 is searched for a matching word or phrase for the utterance provided at block 300. If a match is not found, then the dictation grammar 216 is enabled. In the preferred embodiment, the dictation grammar 216 is a BNF file that contains a list of words that do not, themselves, have either a parent context or an associated context. For example, in one embodiment applicable to a personal computer, the dictation grammar 216 contains a relatively large list of general words similar to a general dictionary.

In block 316 the dictation grammar is searched for matching words for each word of the utterance provided at block 300. If no matching words are found, a visual error message is optionally displayed at the display 104 or an audible error message is optionally reproduced through speaker 112, and the process ends until another utterance is provided to the speech processor 200 at block 300.

Thus, as can be seen from the above description, when an utterance is provided to the speech processor 200, the enabled context-specific grammar 212, if any, is first searched. If there are no matches in the enabled context-specific grammar 212, then the general grammar 214 is enabled and searched. If there are no matches in the general grammar 214, then the dictation grammar 316 is enabled and searched.

In the preferred embodiment, when the speech recognition processor 200 is searching either the context-specific grammar 212 or the general grammar 214, it is said to be in the "command and control" mode. In this mode, the speech

recognition processor 200 compares the entire utterance as a whole to the entries in the grammar. By contrast, when the speech recognition processor 200 is searching the dictation grammar, it is said to be in the "dictation" mode. In this mode, the speech recognition processor 200 compares the utterance to the entries in the dictation grammar 216 one word at a time. It is expected that searching for a match for an entire utterance in the command and control mode will generally be faster than searching for one word at a time in dictation mode.

It is further expected that any individual context-specific grammar 212 will be smaller in size (i.e., fewer total words and phrases) than the general grammar 214, which in turn will be smaller in size than the dictation grammar 216. Thus, by searching any enabled context-specific grammar 212 first, it is likely that a match, if any, will be found more quickly, due at least in part to the smaller file size. Likewise, by searching the general grammar 214 before the dictation grammar 216, it is likely that a match, if any, will be found more quickly.

Additionally, as will be explained further below with regard to the ability of the present invention to adaptively add to both the context-specific grammar 212 and the general grammar 214, they will contain the most common utterances. As such, it is expected that a match is more likely to be found quickly in the context-specific grammar 212 or the general grammar 214 than in the dictation grammar 216.

Finally, as will be explained further below, the words and phrases in the enabled context-specific grammar 212 are more likely to be uttered by the user because they are words that are highly relevant to the subject matter about which the user was most recently speaking. This also allows the user to speak in a more conversational style, using sentence fragments, with the meaning of his words being interpreted according to the enabled context-specific grammar 212.

By searching in the above-described sequence, the present invention may search more efficiently than if the searching

were to occur one entry at a time in a single, large list of all expected words and phrases.

Referring back to decision 306, if a match is found in the context-specific grammar 212, then there are three possible next steps shown in FIG. 3A. For each matching entry in the enabled context-specific grammar 212, there may be an associated action to be taken by the speech recognition processor 200. Block 322 shows that one action may be to direct application interface 220 to take some action with respect to a separate software application or entity. For example, application interface 220 may use the Speech Application Programming Interface (SAPI) standard by Microsoft to communicate with an external application. The external application may be directed, for example, to access a particular Internet web site URL or to speak a particular phrase by converting text to speech. Other actions may be taken as will be discussed further below with reference to the NLP database 218 of FIG. 4.

Block 324 shows that another action may be to access a row in the natural language processing (NLP) database 218 directly, thereby bypassing the natural language processing steps described further below. Block 326 shows that another action may be to prepend a word or phrase for the enabled context to the matching word or phrase found in the context-specific grammar 306. For example, if the enabled context were "movies" and the matching utterance were "8 o'clock", the word "movies" would be prepended to the phrase "8 o'clock" to form the phrase "movies at 8 o'clock".

Likewise, if a match is found in the general grammar 214, then the flow may proceed to block 322 where the application interface 220 is directed to take an action as described above, or to block 324 where a row in the NLP database is directly accessed. However, if a match is found in the general grammar 214, no prepending of a context occurs because, as stated above, the entries in the general grammar 214 do not, themselves, have a parent context.

Finally, with reference to FIG. 3A, words may be entered manually via manual input 106. In this case, no speech recognition is required, and yet natural language processing of the entered words is still desired. Thus, the flow proceeds to FIG. 3B.

In FIG. 3B, at block 328, the natural language processor 202 formats the phrase for natural language processing analysis. This formatting is accomplished by string formatter 206 and may include such text processing as removing duplicate spaces between words, making all letters lower case (or upper case), expanding contractions (e.g., changing "it's" to "it is"), and the like. The purpose of this formatting step is to prepare the phrase for parsing.

The flow continues to block 330 where certain "word-variables" are replaced with an associated wildcard function by variable replacer 204 in preparation for accessing the NLP database 218. As used herein, the term "word-variables" refers to words or phrases that represent amounts, dates, times, currencies, and the like. For example, in one embodiment the phrase "what movies are playing at 8 o'clock" would be transformed at block 330 to "what movies are playing at \$time" where "\$time" is a wildcard function used to represent any time value. As another example, in one embodiment the phrase "sell IBM stock at 100 dollars" would be transformed at block 330 to "sell IBM stock at \$dollars" where "\$dollars" is a wildcard function used to represent any dollar value. This step may be accomplished by a simple loop that searches the phrase for key tokens such as the words "dollar" or "o'clock" and replaces the word-variables with a specified wildcard function. In order to keep track of the location in the phrase where the substitution was made, an array may be used. This allows re-substitution of the original word-variable back into the phrase at the same position after the NLP database 218 has been searched.

The purpose of replacing word-variables with an associated wildcard function at block 330 is to reduce the number of entries that must be present in the NLP database 218. For

example, the NLP database 218 would only contain the phrase "what movies are playing at \$time" rather than a separate entry for 8 o'clock, 9 o'clock, 10 o'clock, and so on. The NLP database 218 will be described further below.

5 At block 332, pronouns in the phrase are replaced with proper names by pronoun replacer 211. For example, in one embodiment the pronouns "I", "my" or "mine" would be replaced with the speaker's name. The purpose of this step is to allow user-specific facts to be stored and accessed in the NLP database 218. For example, the sentence "who are my children" would be transformed into "who are Dean's children" where "Dean" is the speaker's proper name. Again, this step may be performed in a simple loop that searches the phrase for pronouns, and replaces the pronouns found with an appropriate proper name. In order to keep track of the locations in the phrase where a substitution was made, an array may be used.

15 In block 334, the individual words in the phrase are weighted according to their relative "importance" or "significance" to the overall meaning of the phrase by word weighter 208. For example, in one embodiment there are three weighting factors assigned. The lowest weighting factor is assigned to words such as "a", "an", "the" and other articles. The highest weighting factor is given to words that are likely to have a significant relation to the meaning of the phrase. For example, these may include all verbs, nouns, adjectives, and proper names in the NLP database 218. A medium weighting factor is given to all other words in the phrase. The purpose of this weighting is to allow for more powerful searching of the NLP database 218.

25 For example, these may include all verbs, nouns, adjectives, and proper names in the NLP database 218. A medium weighting factor is given to all other words in the phrase. The purpose of this weighting is to allow for more powerful searching of the NLP database 218.

30 An example of selected columns of the NLP database 218 of one embodiment is shown in FIG. 4. The NLP database 218 comprises a plurality of columns 400-410, and a plurality of rows 412A-412N. In column 400, the entries represent phrases that are "known" to the NLP database. In column 402, a number of required words for each entry in column 400 is shown. In column 404, an associated context or subcontext for each entry in column 400 is shown. In columns 408 and 410, one or more

associated actions are shown for each entry in column 400. It should be noted that the NLP database 218 shown in FIG. 4 is merely a simplified example for the purpose of teaching the present invention. Other embodiments may have more or fewer columns with different entries.

Referring back to FIG. 3B, at block 336, the NLP database 218 is searched for possible matches to the phrase, based on whether the entry in column 400 of the NLP database 218 contains any of the words in the phrase (or their synonyms), and the relative weights of those words. At block 338, a confidence value is generated for each of the possible matching entries based on the number of occurrences of each of the words in the phrase and their relative weights. Weighted word searching of a database is well known in the art and may be performed by commercially-available search engines such as the product "dtsearch" by DT Software, Inc. of Arlington, Virginia. Likewise, searching using synonyms is well known in the art and may be accomplished using such publicly-available tools such as "WordNet", developed by the Cognitive Science Laboratory of Princeton University in Princeton, New Jersey. The search engine may be an integral part of the natural language processor 202.

At decision 340, the natural language processor 202 determines whether any of the possible matching entries has a confidence value greater than or equal to some predetermined minimum threshold, T. The threshold T represents the lowest acceptable confidence value for which a decision can be made as to whether the phrase matched any of the entries in the NLP database 218. If there is no possible matching entry with a confidence value greater than or equal to T, then the flow proceeds to block 342 where an optional error message is either visually displayed to the user over display 104 or audibly reproduced over speaker 112. In one embodiment, the type of error message, if any, displayed to the user may depend on how many "hits" (i.e., how many matching words from the phrase) were found in the highest-confidence NLP database entry. A different type of error message would be generated

if there was zero or one hits, than if there were two or more hits.

If, however, there is at least one entry in the NLP database 218 for which a confidence value greater than or equal to T exists, then the flow proceeds to block 344 where the "noise" words are discarded from the phrase. The "noise" words include words which do not contribute significantly to the overall meaning of the phrase relative to the other words in the phrase. These may include articles, pronouns, conjunctions, and words of a similar nature. "Non-noise" words would include words which contribute significantly to the overall meaning of the phrase. "Non-noise" words would include verbs, nouns, adjectives, proper names, and words of a similar nature.

The flow proceeds to FIG. 3C where the non-noise word requirement is retrieved from column 402 of the NLP database 218 for the highest-confidence matching entry at block 346. For example, if the highest-confidence matching phrase was the entry in row 412A, (e.g., "what movies are playing at \$time"), then the number of required non-noise words is 3.

At decision 348, a test is made to determine whether the number of required non-noise words from the phrase is actually present in the highest-confidence entry retrieved from the NLP database 218. This test is a verification of the accuracy of the relevance-style search performed at block 336, it being understood that an entry may generate a confidence value higher than the minimum threshold, T, without being an acceptable match for the phrase.

The nature of the test performed at decision 348 is a boolean "AND" test performed by boolean tester 210. The test determines whether each one of the non-noise words in the phrase (or its synonym) is actually present in the highest-confidence entry. If there are a sufficient number of required words actually present in the highest-confidence entry, then the flow proceeds to block 350, where the natural language processor 202 directs application interface 220 to

take an associated action from column 408 or 410. It is understood that additional action columns may also be present.

For example, if the highest confidence entry was the entry in row 412A, and the boolean test of decision 348 determined that there actually were 3 non-noise words from the phrase in the entry in column 400, then the associated action in column 408 (e.g., access movie web site) would be taken. Other entries in the NLP database have other associated actions. For example, if the highest-confidence entry is that in row 412E (e.g., "what time is it"), the associated action may be for natural language processor 202 to direct a text-to-speech application (not shown) to speak the present time to the user through the speaker 112. As another example, if the highest-confidence entry is that in row 412N (e.g., "show me the news"), the first associated action may be to access a predetermined news web site on the Internet, and a second associated action may be to direct an image display application (not shown) to display images associated with the news. Different or additional actions may also be performed.

Also, if the highest-confidence entry contains the required number of non-noise words from the phrase as determined at decision 348, the natural language processor 202 instructs the speech recognition processor 200 to enable the context-specific grammar 212 for the associated context of column 404. Thus, for row 412A, context-specific grammar 212 for the context "movies" would be enabled. Thus, when the next utterance is provided to the speech recognition processor 200 in block 300 of FIG. 3A, it would search the enabled context-specific grammar 212 for "movies" before searching the general grammar 214. As previously stated, enabling the appropriate context-specific grammar 212 greatly increases the likelihood of fast, successful speech recognition, and enhances the user's ability to communicate with the computer in a conversational style.

If, however, back at decision 348, the required number of non-noise words from the phrase is not actually present in the highest-confidence entry retrieved from the NLP database 218,

then the flow proceeds to block 354 where the user is prompted over display 104 or speaker 112 whether the highest-confidence entry was meant. For example, if the user uttered "How much is IBM stock selling for today", the highest-confidence entry in the NLP database 218 may be the entry in row 412B. In this case, although the relevance factor may be high, the number of required words (or their synonyms) may not be sufficient. Thus, the user would be prompted at block 354 whether he meant "what is the price of IBM stock on August 28, 1998".

The user may respond either affirmatively or negatively. If it is determined at decision 356 that the user has responded affirmatively, then the action(s) associated with the highest-confidence entry are taken at block 350, and the associated context-specific grammar 212 enabled at block 352.

If, however, it is determined at decision 356 that the user has responded negatively, then the flow proceeds to FIG. 3D where the associated context from column 404 of NLP database 218 is retrieved for the highest-confidence entry, and the user is prompted for information using a context-based interactive dialog at block 360. For example, if the user uttered "what is the price of XICOR stock today", and the highest confidence entry from the NLP database 218 was row 412B (e.g., "what is the price of IBM stock on \$date), then the user would be prompted at block 354 whether that was what he meant.

If the user responds negatively, then the context "stock" is retrieved from column 404 at block 358, and the context-based interactive dialog for the stock context is presented to the user over the display 104 and speaker 112. Such a context-based interactive dialog may entail prompting the user for the name and stock ticker symbol of XICOR stock. The user may respond by speaking the required information. A different context-based interactive dialog may be used for each of the possible contexts. For example, the "weather" context-based interactive dialog may entail prompting the user for the name of the location (e.g., the city) about which weather information is desired. Also, the "news" context-based

interactive dialog may entail prompting the user for types of articles, news source, Internet URL for the news site, or other related information.

5 Upon completion of the context-based interactive dialog, the NLP database 218, general grammar 214, and context-specific grammar 212 are updated to include the new information. In this way, the next time the user asks for that information, a proper match will be found, and the appropriate action taken without prompting the user for more
10 information. Thus, the present invention adaptively "learns" to recognize phrases uttered by the user.

 In one embodiment of the present invention, one or more of the NLP database 218, context specific grammar 212, general grammar 214, and dictation grammar 216 also contain time-stamp
15 values (not shown) associated with each entry. Each time a matching entry is used, the time-stamp value associated with that entry is updated. At periodic intervals, or when initiated by the user, the entries that have a time-stamp value before a certain date and time are removed from their
20 respective databases/grammars. In this way, the databases/grammars may be kept to an efficient size by "purging" old or out-of-date entries. This also assists in avoiding false matches.

 In summary, the present invention provides a method and
25 system for an interactive user-interface for a computer. By the use of context-specific grammars, the present invention decreases speech recognition time and increases the user's ability to communicate with the computer in a conversational style. Furthermore, by the use of adaptive updating of the
30 various grammars and the NLP database, the present invention further increases interactive efficiency.

 The previous description of the preferred embodiments is provided to enable any person skilled in the art to make or
35 use the present invention. The various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without the use of inventive faculty.

Thus, the present invention is not intended to be limited to the embodiments shown herein, but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

5

I CLAIM:

CLAIMS

1. A method for interacting with a computer using utterances, the method comprising the steps of:

5 searching a first grammar file for a matching phrase for said utterance;

searching a second grammar file for said matching phrase if said matching phrase is not found in said first grammar file;

10 searching a database for a matching entry for said matching phrase; and

performing an action associated with said matching entry if said matching entry is found in said database.

2. The method of claim 1 further comprising the step of updating at least one of said database, said first grammar file and said second grammar file with said matching phrase if said matching entry is not found in said database.

3. The method of claim 2 wherein said first grammar file is a context-specific grammar file.

4. The method of claim 3 wherein said second grammar file is a general grammar file.

5. The method of claim 4 further including the step of searching a dictation grammar for said matching phrase if said matching phrase is not found in said general grammar file.

6. The method of claim 1 further comprising the step of replacing at least one word in said matching phrase prior to said step of searching said database.

7. The method of claim 6 wherein said step of replacing said at least one word comprises substituting a wildcard for said at least one word.

8. The method of claim 6 wherein said step of replacing said at least one word comprises substituting a proper name for said at least one word.

9. The method of claim 1 further comprising the step of text formatting said matching phrase prior to said step of searching said database.

10. The method of claim 1 further comprising the step of weighting individual words in said matching phrase according

to a relative significance of said individual words prior to said step of searching said database.

11. The method of claim 1 further comprising the step of generating a confidence values for said matching entry.

5 12. The method of claim 11 further comprising the step of comparing said confidence value with a threshold value.

13. The method of claim 12 further comprising the step of determining whether a required number of words from said matching phrase are present in said matching entry.

10 14. The method of claim 13 further comprising the step of prompting a user whether said matching entry is a correct interpretation of said utterance if said required number of words from said matching phrase are not present in said matching entry.

15 15. The method of claim 14 further comprising the step of prompting a user for additional information if said matching entry is not a correct interpretation of said utterance.

20 16. The method of claim 15 further comprising the step of updating at least one of said database, said first grammar file and said second grammar file with said additional information.

25 17. The method of claim 2 further comprising the step of searching a context-specific grammar associated with said matching entry for a subsequent matching phrase for a subsequent utterance.

18. A system for interacting with a computer using utterances, the system comprising:

30 a speech processor for searching a first grammar file for a matching phrase for said utterance, and for searching a second grammar file for said matching phrase if said matching phrase is not found in said first grammar file;

a natural language processor for searching a database for a matching entry for said matching phrase; and

35 an application interface for performing an action associated with said matching entry if said matching entry is found in said database.

19. The system of claim 18 wherein said natural language processor updates at least one of said database, said first grammar file and said second grammar file with said matching phrase if said matching entry is not found in said database.

5 20. The system of claim 19 wherein said first grammar file is a context-specific grammar file.

21. The system of claim 20 wherein said second grammar file is a general grammar file.

10 22. The system of claim 21 wherein said speech processor searches a dictation grammar for said matching phrase if said matching phrase is not found in said general grammar file.

23. The system of claim 18 further wherein said natural language processor replaces at least one word in said matching phrase prior to searching said database.

15 24. The system of claim 23 further comprising a variable replacer in said natural language processor for substituting a wildcard for said at least one word in said matching phrase.

20 25. The system of claim 23 further comprising a pronoun substituter in said natural language processor for substituting a proper name for said at least one word in said matching phrase.

26. The system of claim 18 further comprising a string formatter for text formatting said matching phrase prior to searching said database.

25 27. The system of claim 18 further comprising a word weighter for weighting individual words in said matching phrase according to a relative significance of said individual words prior to searching said database.

30 28. The system of claim 18 further comprising a search engine in said natural language processor for generating a confidence value for said matching entry.

29. The system of claim 28 wherein said natural language processor compares said confidence value with a threshold value.

35 30. The system of claim 29 further comprising a boolean tester for determining whether a required number of words from said matching phrase are present in said matching entry.

31. The system of claim 30 wherein said natural language processor prompts a user whether said matching entry is a correct interpretation of said utterance if said required number of words from said matching phrase are not present in said matching entry.

32. The system of claim 30 wherein said natural language processor prompts a user for additional information if said matching entry is not a correct interpretation of said utterance.

33. The system of claim 32 wherein said natural language processor updates at least one of said database, said first grammar file and said second grammar file with said additional information.

34. The system of claim 19 wherein said speech processor searches a context-specific grammar associated with said matching entry for a subsequent matching phrase for a subsequent utterance.

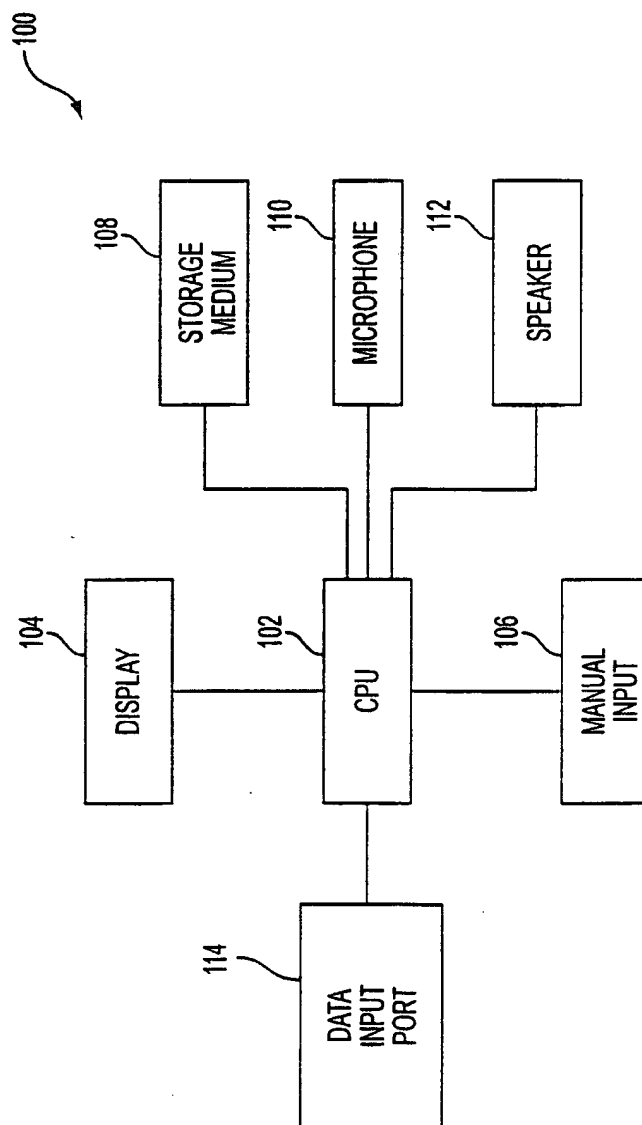


FIG. 1

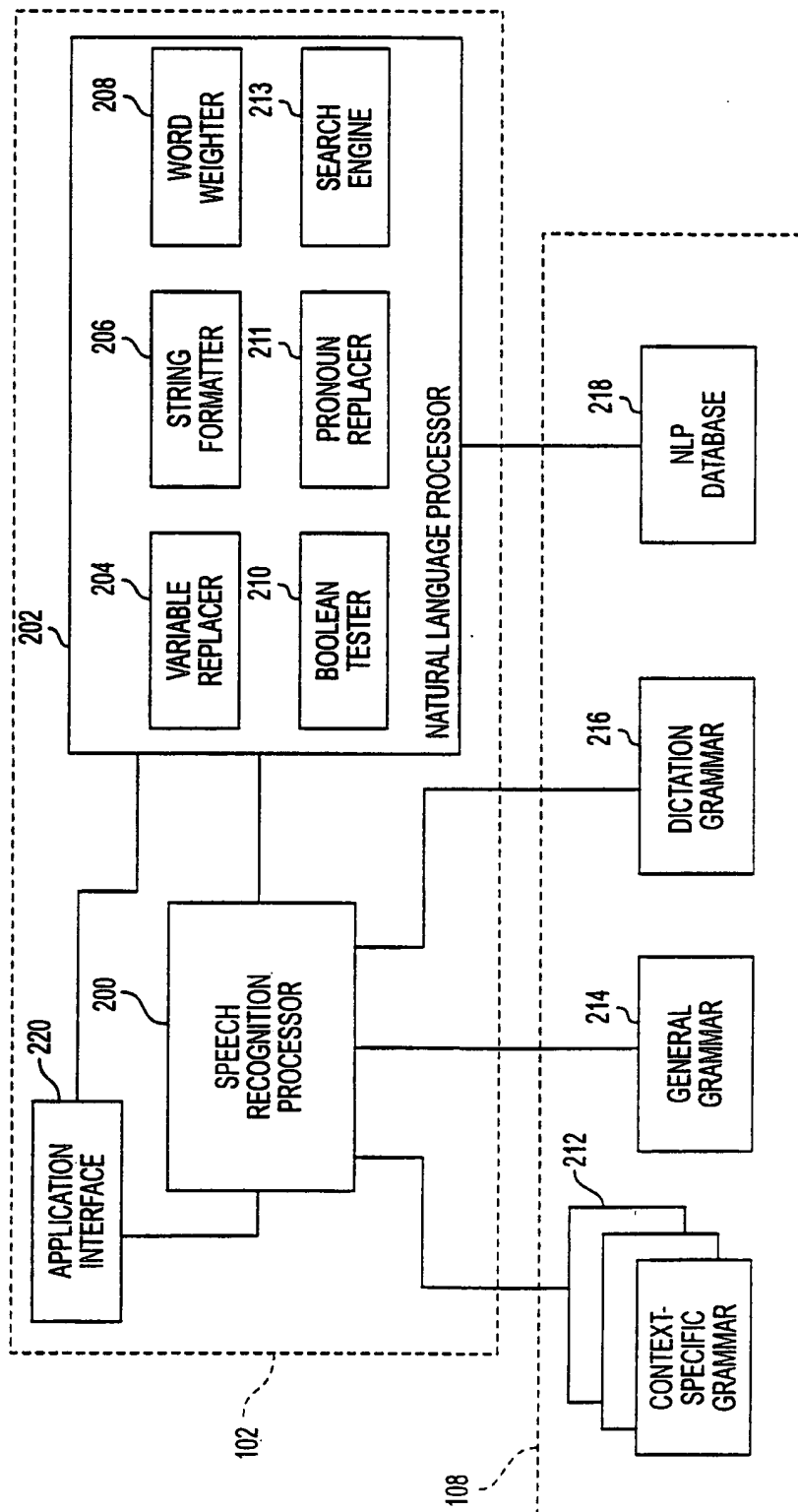


FIG. 2

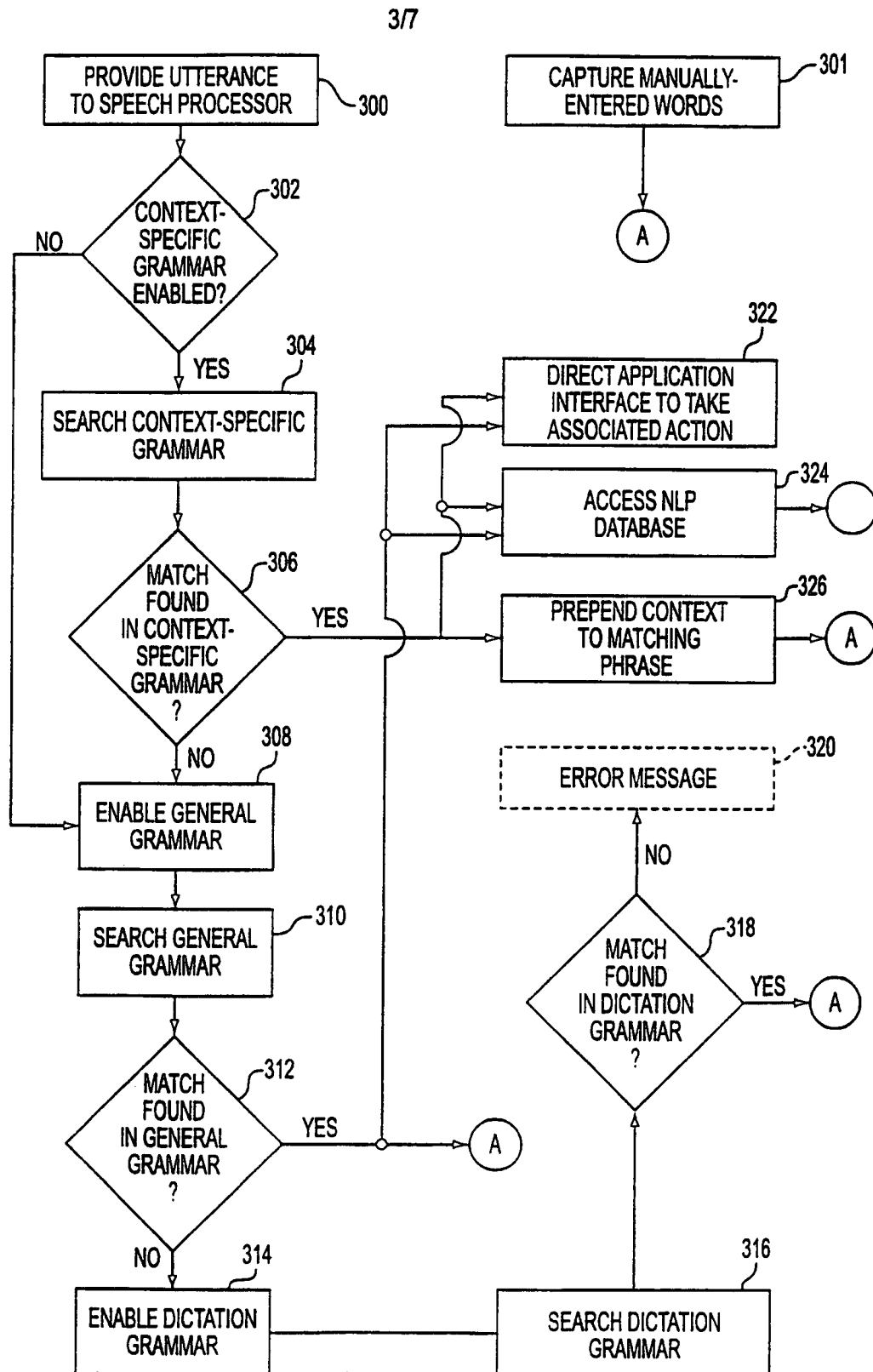


FIG. 3A

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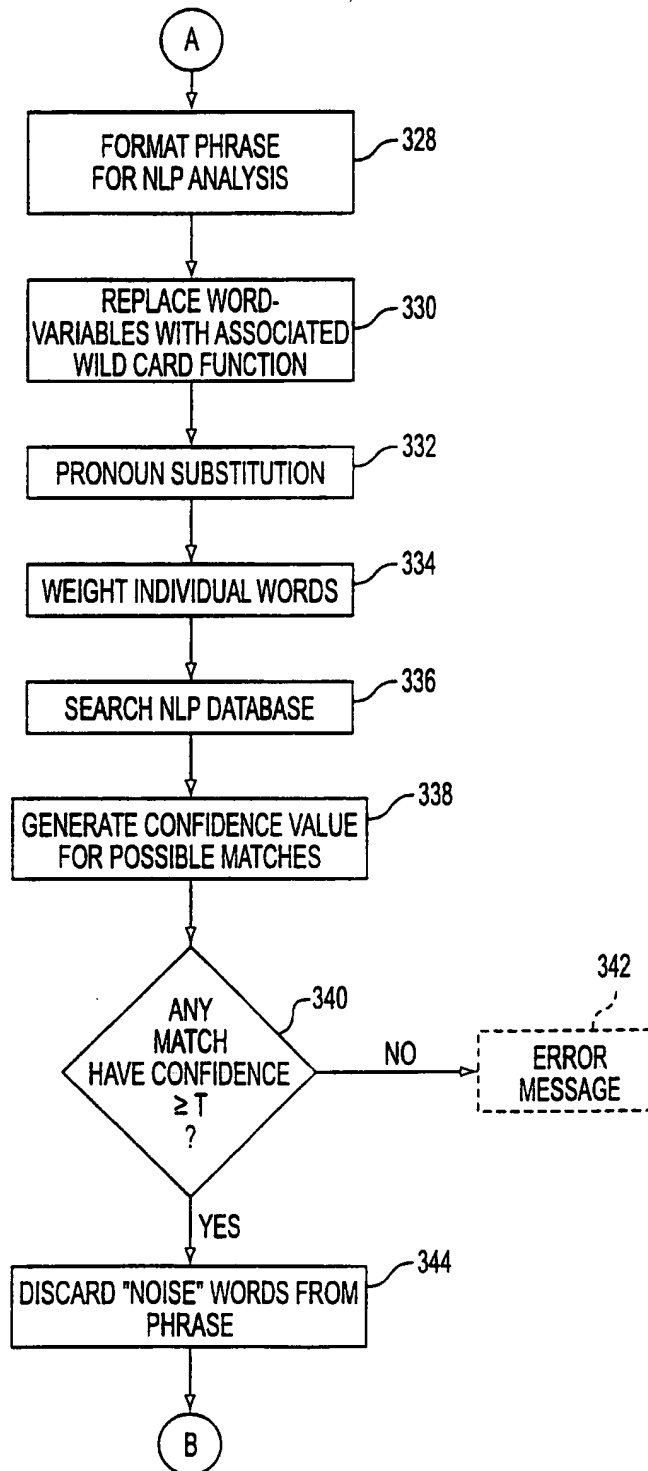


FIG. 3B

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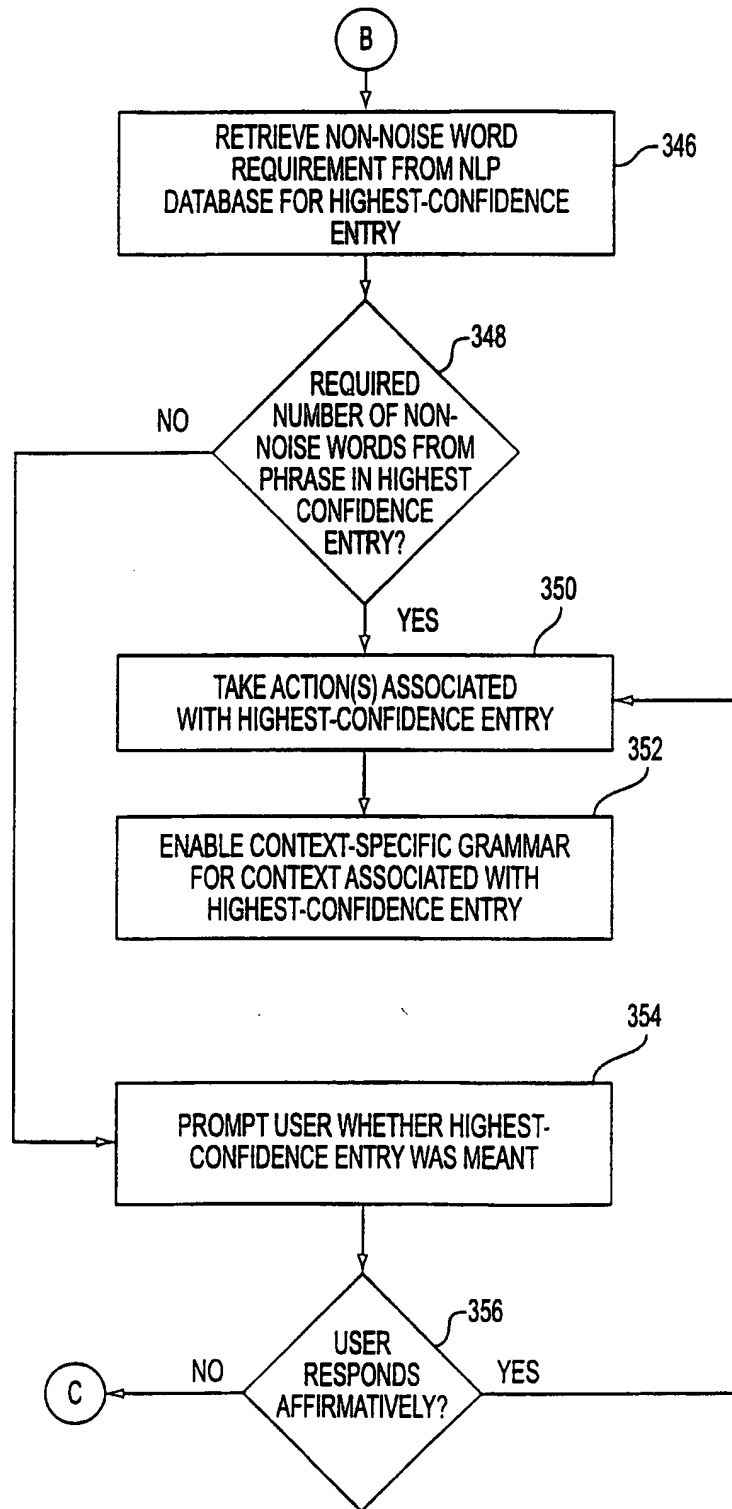


FIG. 3C

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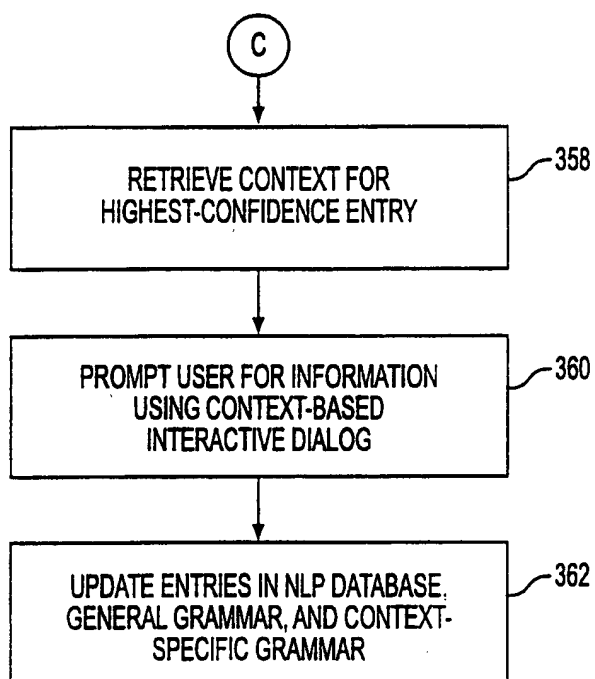


FIG. 3D

218 {

400 PHRASE	402 REQUIRED WORDS	404 CONTEXT/ SUB CONTEXT	408 ACTION 1	410 ACTION 2
412A WHAT MOVIES ARE PLAYING AT \$ TIME	3	MOVIES	ACCESS MOVIE WEB SITE	N/A
412B WHAT IS THE PRICE OF IBM STOCK ON \$ DATE	4	STOCKS	ACCESS STOCK PRICE WEB SITE	N/A
412C SELL IBM STOCK AT \$ DOLLARS	4	STOCKS	ACCESS STOCK TRADE WEB SITE	N/A
412D WHAT IS THE WEATHER IN \$ LOCATION	3	WEATHER	ACCESS WEATHER WEB SITE	N/A
412E WHAT TIME IS IT	2	TIME	N/A	TEXT-TO SPEECH OF TIME
412N SHOW ME THE NEWS	2	NEWS	ACCESS NEWS WEB SITE	DISPLAY IMAGES

FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 99/20445

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 G10L15/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G10L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>EP 0 834 862 A (LUCENT TECHNOLOGIES INC) 8 April 1998 (1998-04-08)</p> <p>page 2, line 10-14 page 2, line 25-29 page 2, line 56-58 page 3, line 31-48</p> <p>---</p> <p>-/--</p>	<p>1,3, 10-12, 17,18, 20, 27-29,34</p>

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

10 January 2000

Date of mailing of the international search report

18/01/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Quélavoine, R

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/20445

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>"APPROXIMATE WORD-SPOTTING METHOD FOR CONSTRAINED GRAMMARS"</p> <p>IBM TECHNICAL DISCLOSURE BULLETIN, US, IBM CORP. NEW YORK, vol. 37, no. 10, 10 October 1994 (1994-10-10), page 385 XP000475707 ISSN: 0018-8689 page 385, line 4-6 page 385, line 12-16</p> <p>---</p>	<p>1,6-9, 18,23-26</p>
A	<p>"SPREADSHEET PROGRAM ACCEPTING CONTINUOUS-SPEECH INPUT"</p> <p>IBM TECHNICAL DISCLOSURE BULLETIN, US, IBM CORP. NEW YORK, vol. 38, no. 12, 12 December 1995 (1995-12-12), page 357-359 XP000588170 ISSN: 0018-8689 page 357, line 3-5 page 358, line 5-7 page 358, line 18-20 page 358, line 33-35</p> <p>---</p>	<p>1,3,10, 17,18, 20,27,34</p>
A	<p>US 5 311 429 A (TOMINAGA MASASUKE) 10 May 1994 (1994-05-10) abstract column 2, line 35-39 column 2, line 44-50 column 3, line 22-56</p> <p>---</p>	<p>15,16, 32,33</p>
A	<p>"TECHNIQUES FOR SPEECH RECOGNITION"</p> <p>IBM TECHNICAL DISCLOSURE BULLETIN, US, IBM CORP. NEW YORK, vol. 38, no. 12, 12 December 1995 (1995-12-12), page 341-342 XP000588164 ISSN: 0018-8689 page 341, line 14-17 page 341, line 35-37 page 342, line 11-14</p> <p>---</p>	<p>1,3,17, 18,20,34</p>
A	<p>PATENT ABSTRACTS OF JAPAN vol. 1996, no. 06, 28 June 1996 (1996-06-28) & JP 08 044384 A (NEC CORP), 16 February 1996 (1996-02-16) abstract</p> <p>-----</p>	<p>1,10-16, 18,27-33</p>

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Information on patent family members

International Application No

PCT/US 99/20445

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